# PESTICIDE SPRAY DRIFT CONFERENCE

## Droplet Spectra for Aerial Applicators

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U.S. Department of Agriculture

# ORIGIN OF STANDARDIZED SPRAY DROPLET SIZE CATEGORIES

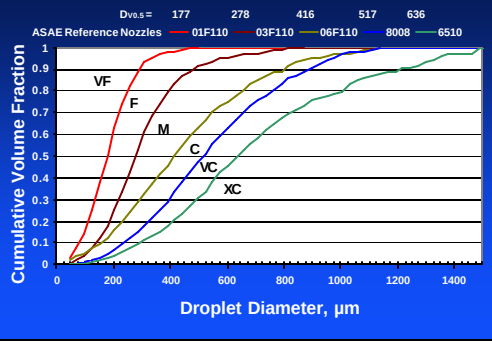
- **1985 -- British Crop Protection Council (BCPC)**
  - Droplet size classifications, primarily designed to enhance efficacy.
  - Uses the term **SPRAY QUALITY** for droplet size categories.
- **2000 -- ASAE Standard S572**
  - Droplet size classifications, primarily designed to control spray drift.
  - Uses the term **DROPLET SPECTRA CLASSIFICATION** for droplet size categories.

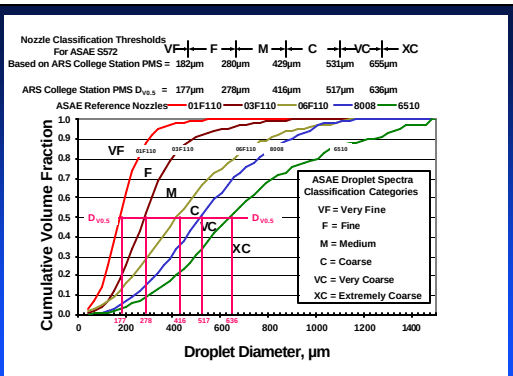
# DROPLET SPECTRA CLASSIFICATION IS SPECIFIC TERMINOLOGY THAT WILL BE USED ON PRODUCT LABELS AND IS RELATED TO VOLUME MEDIAN DIAMETER FROM AN ASAE REFERENCE NOZZLE SET WITH A LASER REFERENCE INSTRUMENT*

| | |
|---|---|
| Very Fine (VF) | < 182µm |
| Fine (F) | 183-280µm |
| Medium (M) | 281-429µm |
| Coarse (C) | 430-531µm |
| Very Coarse (VC) | 532-655µm |
| Extremely Coarse (XC) | >656µm |

*USDA ARS College Station, TX PMS

# REFERENCE CURVES FOR ASAE S572 REFERENCE NOZZLES PMS SYSTEM, USDA, ARS, COLLEGE STATION, TX



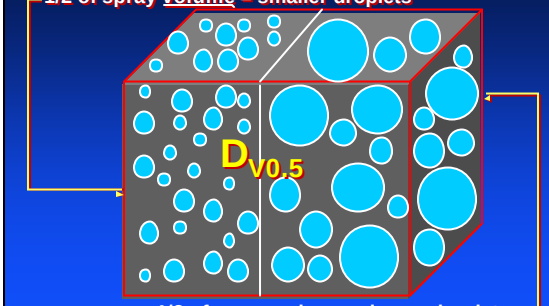




# WHAT DO THESE SIZES MEAN IN RELATIVE TERMS ?

| | |
|---|---|
| Very Fine (VF) | human hair |
| Fine (F) | sewing thread |
| Medium (M) | tooth brush bristle |
| Coarse (C) | staple |
| Very Coarse (VC) | paper clip |
| Extremely Coarse (XC) | #2 pencil lead |

## VOLUME MEDIAN DIAMETER (VMD) $D_{V0.5}$

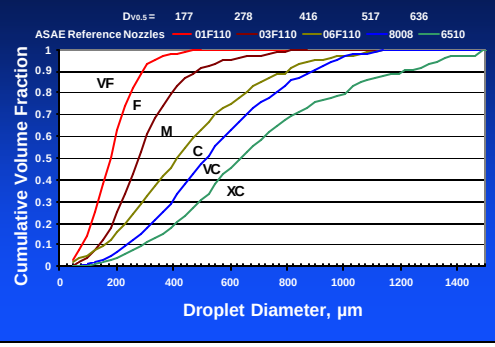
1/2 of spray volume = smaller droplets




Source: R. E. Wolf

1/2 of spray volume = larger droplets

## REFERENCE CURVES FOR ASAE S572 REFERENCE NOZZLES
## PMS SYSTEM, USDA, ARS, COLLEGE STATION, TX




## THE LABEL IS THE LAW

**Directions for use**

It is a violation of federal law to use this product in a manner inconsistent with its labeling.

## WHAT ARE WE ACCUSTOMED TO SEEING ON LABELS ?

- Use nozzle types and arrangements that will provide optimum spray distribution and maximum coverage . . . Classic, 1998
- The best drift management strategy is to apply the largest droplets that provide sufficient coverage and control. Hyvar X-L, 1998 & Furadan 4F, 1999

-- general statements and precautions --

## WHAT NEW TERMS ARE WE SEEING ON LABELS ?

- . . . desired droplet size (100 - 200µm) . . . Lock-On (chlorpyrifos), 2001 (very fine -- fine)
- . . . apply in spray droplet size of 200-300 µm . . . Tracer (spinosad), 2001 (medium)
- . . . use coarse spray droplets . . . (430-530µm) Reclaim (clopyralid), 2001

*How do applicators comply with the law when label language is this specific?*

## PRACTICAL SOURCES FOR DROPLET SPECTRA CLASSIFICATION INFORMATION

- Technical literature
- Nozzle manufacturers literature (ground)
- Spray Drift Task Force database
  - Ground systems
  - Orchard airblast systems
  - Aerial systems
    - DropKick
    - AgDRIFT
      - DropKick
      - USDA aerial nozzle models

(aerial)

- USDA aerial nozzle models

## USDA AERIAL NOZZLE MODELS

### Applicability and Limitations:

- Specific nozzle class
- Account for airspeed/air shear
- Account for major influence of spray mix properties
- Models currently available
  - Eight fixed-wing nozzle models
  - Eight helicopter nozzle models

## NOZZLE USE IN AERIAL APPLICATION

| Nozzle | Composite Utilization, % | |
|---|---|---|
| | Fixed-wing | Rotary-wing |
| CP-03 | 42 * | 30 * |
| CP Str. Stream | 25 * | 8 † |
| Disc Orif. Str. Stream | 8 * | 15 * |
| Flat Fan | 5 * * | 2 †* * |
| Disc-Core | 5 * * | 12 * |
| Lund Str. Stream | 4 * | 2 |
| Accu-Flo | 4 | 16 * * |
| Micronair | 3 | 5 |
| Raindrop RD | 2 | 8 * |
| Flood | 2 | |
| TVB | | 2 |

Source:

Survey 1999

*Nozzle Models Available

## AERIAL NOZZLE MODEL DEVELOPMENT

### Objective:

- Develop a readily usable tool for aerial applicators to predict Droplet Spectra Classification from predominantly used nozzles in both fixed-wing and rotary-wing segments of the aerial application industry

## AERIAL NOZZLE MODEL DEVELOPMENT

### Fixed-Wing Study Equipment:

- **Wind tunnel test facility**
  - Nozzle angle, general: 0° - 90°, low drift: 0° - 20°
  - Nozzle size, range based on survey
  - Airspeed, 100 to 160 mph
  - Pressure, 20 to 60 psi
  - PMS laser probe

## AERIAL NOZZLE MODEL DEVELOPMENT

### Helicopter Study Equipment:

- **Wind tunnel test facility**
  - Nozzle angle, general: 0° - 90°, low drift: 0° - 20°
  - Nozzle size, range based on survey
  - Airspeed, 30 to 100 mph
  - Pressure, 20 to 60 psi
  - PMS laser probe

## AERIAL NOZZLE MODEL DEVELOPMENT

### Study Equipment:

Examples --

- Disc Orifice 46 Core Nozzle
  - Orifice Sizes: 2 - 10
  - Nozzle Angles: 0° - 90°
- CP-03 Nozzle
  - Nozzle axis parallel with airstream
  - Orifice Sizes: 0.061 - 0.171
  - Nozzle Deflector Angles: 30°, 55°, 90°

## AERIAL NOZZLE MODEL DEVELOPMENT

### Spray Mix:

- Tap water
- 0.25% v/v Triton X-100

## AERIAL NOZZLE MODEL DEVELOPMENT

### Procedure:

- Experimental Design
  - 27 Different Combinations of
    - Orifice Size, or Nozzle Size
    - Nozzle Angle, or Deflector Angle
    - Spray Pressure
    - Airspeed
  - Each combination scanned in 4 passes with laser spectrometer in wind tunnel and that process was replicated 3 times for each of the 27 combinations for each nozzle

## AERIAL NOZZLE MODEL DEVELOPMENT

### Procedure:

- PMS laser spectrometer data selection
  - Volume median diameter, $D_{V0.5}$
  - Relative span, RS, measure of range of mid 80 % of spray spectrum
  - % Spray volume in droplets < 100 µm diameter
  - % Spray volume in droplets < 200 µm diameter
  - Droplet Spectra Classification (Computed classification based on $D_{V0.5}$ from nozzle under test, reference nozzle dataset, and ASAE S572)

## AERIAL NOZZLE MODEL DEVELOPMENT

### Data Analysis:

$$Y = A + BX_1 + CX_2 + DX_3 + EX_4 + FX_1^2 + GX_2X_1 + HX_2^2 + IX_3X_1 + JX_3X_2 + KX_3^2 + LX_4X_1 + MX_4X_2 + NX_4X_3 + OX_4^2$$

## FIXED-WING NOZZLE MODEL
### Spreadsheet for Disc Orifice Straight Stream Nozzle

DISC ORIFICE STRAIGHT STREAM NOZZLE

FOR USE ON FIXED-WING AIRCRAFT

Quotation from this work should be as follows: Kirk, I. W. "Droplet Spectra Classification for Fixed-Wing Aircraft Spray Nozzles." Presented at the ASAE 94th Annual International Meeting, Sacramento, CA, July 31, 2001, Paper Number 01-1082. ASAE, 2950 Niles Rd., St. Joseph, MI 49085-9659 USA. Telephone (616) 429-0300, Facsimile (616) 429-3852.

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F I X E D - W I N G

Directions: Enter DISC ORIFICE nozzle parameters, pressure, and airspeed in the cells highlighted below.
(Application parameters are valid only with nozzle parameters specified in the Acceptable Range.)

| | Orifice Size, | Nozzle Angle, degrees | Pressure, psi | Airspeed, mph |
|---|---|---|---|---|
| Acceptable Range: | 4 to 12 | 0 to 20 | 20 to 60 | 100 to 160 |
| | 12 | 0 | 30 | 130 |

Application parameters are displayed in the box below.

| | | |
|---|---|---|
| $D_{V0.5}$ = | 328 µm | = Volume median diameter |
| RS = | 1.31 | = Relative Span |
| V<100µm = | 5.36 % | = Percentage of spray volume in droplets smaller than 100 µm diameter. |
| V<200µm = | 14.04 % | = Percentage of spray volume in droplets smaller than 200 µm diameter. |
| DSC = | MEDIUM | = Droplet Spectra Classification. |

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F I X E D - W I N G

Directions: Enter DISC ORIFICE nozzle parameters, pressure, and airspeed in the cells highlighted below.
(Application parameters are valid only with nozzle parameters specified in the Acceptable Range.)

| | Orifice Size, | Nozzle Angle, degrees | Pressure, psi | Airspeed, mph |
|---|---|---|---|---|
| Acceptable Range: | 4 to 12 | 0 to 20 | 20 to 60 | 100 to 160 |
| | 10 | 0 | 40 | 120 |

Application parameters are displayed in the box below.

| | | |
|---|---|---|
| $D_{V0.5}$ = | 518 µm | = Volume median diameter |
| RS = | 1.32 | = Relative Span |
| V<100µm = | 0.92 % | = Percentage of spray volume in droplets smaller than 100 µm diameter. |
| V<200µm = | 3.16 % | = Percentage of spray volume in droplets smaller than 200 µm diameter. |
| DSC = | COARSE | = Droplet Spectra Classification. |

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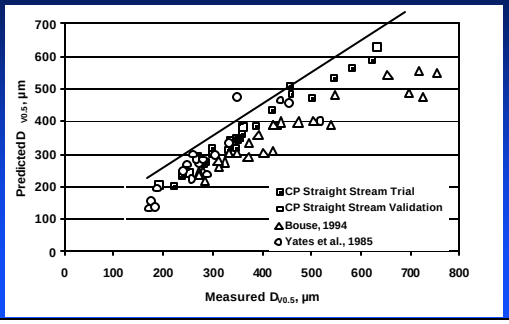
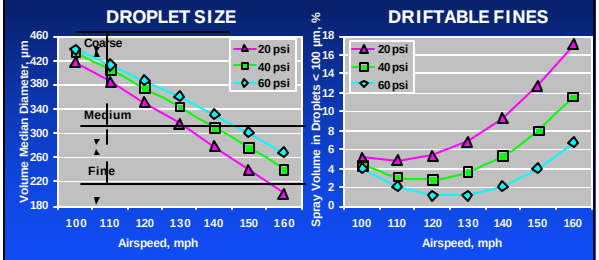
## AERIAL NOZZLE MODEL
### Validation of Model Predictions




## 40° FLAT FAN NOZZLE MODEL GRAPHS
### 4008 Orifice Tip, 0° Nozzle Angle



## AERIAL NOZZLE MODELS
### Summary:

- Use of these aerial nozzle models will permit users of aerial nozzles to be responsible stewards in the use of crop protection materials
- Regulatory decisions on details of use of these models will facilitate compliance with label requirements for aerial application with a specific spray droplet spectra classification

## AERIAL NOZZLE MODELS
### Availability:

- Diskettes with spreadsheet models will be provided based on request
- Interactive models are posted on USDA ARS APMRU Internet homepage
- USDA will publish an Aerial Applicators Spray Nozzle Handbook based on the models
- NAAA has committed to purchase copies of the Handbook for distribution to NAAA members, additional copies will be available from GPO, NTIS

## AERIAL NOZZLE MODELS
### Availability:

USDA ARS APMRU Internet homepage for access to aerial spray nozzle models:

**http://apmru.usda.gov**
**Downloads**

## -- TIME FOR QUESTIONS --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